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Thesis.

# RETENTION IN GENERAL SCIENCE

by

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## Chapter I

## Previous Studies in Retention

Within the last half-century many investigations with regard to memory and forgetting have been made. Both psychologists and educators have contributed valuable studies. These involve the use of a variety of material, such as nonsense syllables, figures, poetry, prose selections, and lists of words.

Most of the studies have been laboratory experiments. Those few investigations designed to measure retention of material normally presented in the class room have been chosen for detailed presentation. All the references cited are to studies published within the last ten years.

But the laboratory experiments of Ebbinghaus and Radossawljewitsch have exerted such profound influence on present day pedagogy that they must not pass unmentioned. The experiments of Ebbinghaus in 1885 laid the foundations for future experimental investigation. His curve of forgetting, derived from his classic experiments with nonsense syllables, in which he served in the dual capacity of subject and experimenter, has greatly influenced educational procedures of today. He found that a large amount of forgetting follows the learning and that with the lengthening of time forgetting decreases.

P. R. Radossawljewitsch, another German psychologist, used both meaningful material and nonsense syllables in the investigation which he made, using both adults and children as subjects. His conclusions parallel those that Ebbinghaus

reached two decades before - that forgetting occurs rapidly directly following the learning and then gradually slows up He concluded, too, that nonsense material is more easily forgotten than meaningful material.

Clifford Woody [1] (1922) attempted to throw light upon the amount of algebra retained by high school seniors in one of the large high schools in Michigan. In this high school two years of algebra were offered, but only one year was required of all students. This one year was usually required during the freshman year, so that many of the seniors had finished their study of the subject three years previous to the investigation. Some of the students had elected a second year of algebra, and consequently had finished the subject only two years before. Since there was not available an adequate measure of the knowledge that the seniors had when they had completed their study of algebra, it was decided to compare them with those students, mostly freshmen, still taking algebra. Thus 116 seniors were compared with 438 algebra students. This comparison was justified on the grounds that the groups under consideration were large enough to destroy any selective factor and that according to scores on the Army Alpha Test the two groups of students were normal groups.

1. Woody, C. : Scores made by seniors on the Hotz Algebra Scales with scores made by high school students taking algebra. School and Society 16: 303-306, September, 1922.

Each group was given the Hotz Equation and Formula, and Problem Scales. A study of the results obtained showed that the seniors retained a relatively large amount of the manipulative techniques of algebra but a comparatively small amount of procedures in solving problems. They maintained adequate standards on the Equation and Formula Scale, but showed an almost inconceivable inability to solve extremely easy problems.

Another attempt to measure class room retention was made by H. E. Jones [2.] (1923). Before 453 Columbia University students he delivered a series of 40-minute psychology lectures. At the close of each lecture period the students were subjected to an immediate recall test. Delayed recall tests, comprised of different questions, were given at intervals of one, three, seven days, and eight weeks. The investigator found "a rapid initial decrement, from 62 per cent. immediate to 45 per cent. after three or four days, with a slower decrement to 24 per cent. after eight weeks." The largest amount seems to be forgotten during the lecture itself.

In the field of chemistry, S. R. Powers [3.] (1924) studied retention. His tests were given to 349 freshmen at the University of Minnesota. All these students had studied the subject in high school, but the interval from the completion

2. Jones, H. E. : The Effect of Examinations on the Permanence of Learning.
Archives of Psychology, No. 68, pp. 1-70, 1923.

3. Powers, S. R. : A Diagnostic Study of the Subject Matter of High School Chemistry.
Teachers College, Columbia University Contributions to Education, No. 149, pp. 49-54, 1924.

of the course to the time of testing varied from three months to two years or more. A standard median was secured by testing 1200 students who had just completed the course. The data reveal that college students, although a highly selected group of capable individuals, retain but little of the knowledge and skills attained in the class room and laboratory. Most students, apparently, lose almost all their knowledge of the subject matter of chemistry within one or two years after their direct connection with the subject has ceased. Apparently, too, much information imparted in the class room has little or no functional value, for so much of it passes out of the mind soon after instruction.

An investigation carried on by G. A. Yoakum [4.] (1924) measured the effect of a single reading of an article. It was found that a single reading yields on the average less than half of the total ideas in an article. The number of ideas gained varies with the individual and from grade to grade. The investigator questions whether a single reading without any immediate recall will leave any impression on the mind of the learner after a lapse of twenty or thirty days unless the material is very interesting or unusual.

In 1926, Margaret E. Noonan [5.] carried on a study to find out how much of the information acquired in school is

4. Yoakum, G. A. : The Effect of a Single Reading. University of Iowa Studies in Education, II, No. 7, 1924.

5. Noonan, M. E. : Influence of the Summer Vacation on the Abilities of Fifth and Sixth Grade Children. Teachers College, Columbia University Contributions to Education, No. 204, pp.1-103. 1926.

forgotten during the summer vacation. In all 803 fifth and sixth grade children, selected from the public schools of St. Louis, took part in the experiment. Of this number 222 attended a summer school. Such abilities as language ability, reading ability, spelling ability, ability to solve problems in arithmetic, and ability in arithmetical computation were tested by the use of standard tests. The influence of summer school in improving all but two of these abilities, namely, spelling and arithmetical computation, was slight. In spelling and arithmetical computation summer instruction did prevent for the summer school group the slight loss that occurred in the group that did not attend summer school. The results of this investigation have a direct bearing on the policy of intensive reviews at the opening of school in the fall. It would seem that such reviews are largely unnecessary since the amount of forgetting that occurs, in these grades at least, during the vacation period is slight.

Similar conclusions were drawn by G. A. Kramer [6] (1927) from an investigation that attempted to measure the amount of forgetting over the summer vacation in a group of 150 fifth grade children in Baltimore. The group was given tests in reading and arithmetic at the close of school in June and again at the reopening in September. As a group the subjects exhibited

6. Kramer, G. A.: Do Children Forget During the Vacation? Baltimore Bulletin of Education, Vol. 6, No. 3. pp. 56-60, December, 1927.

good retention is arithmetic. In reading there was improvement rather than deterioration with more than 40 per cent. of the children. What forgetting is manifested is not serious.

One of the most comprehensive studies in retention was made by Sarah Janet Bassett [7.] (1928) in the field of history. By means of carefully devised tests it was attempted to measure the amount of history knowledge retained by sixth, seventh, and eighth grade pupils. The subjects were typical children of large city schools, since they were selected to cover wide ranges of intelligence levels, grade progress, chronological ages, interest and effort. The aggregate number involved in the experiment was 1304 boys and girls. The children were given the graded history tests devised by the experimenter at four-month intervals. As soon as a class had completed the required work in history for a given grade, they were given the test for that grade. The class then continued with the advance work, and after a four-month interval it was retested on the work of the previous grade. The test on the work of the grade just completed was also administered. Thus the cycle progressed through the three grades. Of course some children were eliminated for various reasons, but a sufficiently large number was available for the whole experiment to make the findings of the investigation meaningful.

7. Bassett, S. J. : Retention of History in the Sixth, Seventh, and Eighth Grades with Special Reference to the Factors that Influence Retention. The Johns Hopkins University Studies in Education, No. 12, pp. 1-110, 1928.

Not only were the children given tests to secure a measure of history retention but wherever possible the same children were given tests to supply data for the influence of certain factors on retentiveness. Nine such factors were considered: namely, (1) sex, (2) mental age, (3) chronological age, (4) subject preference, (5) interest and effort, (6) reading comprehension, (7) ability to answer questions on a standardized history test, (8) weight, and (9) height.

The following conclusions based upon the data resulting from the investigation are significant. Their application to class room instruction suggest desirable educational procedures.

1. After sixteen months the children know 72 per cent. of the history which they knew at the end of the semester.

2. The largest amount of forgetting is from the initial to the four-month interval. Reviews and examinations should be given soon after learning rather than after long delays.

3. History knowledge which is concrete and personal tends to be well remembered. The kinds of history knowledge which are forgotten relate to a confusion of names and geographical locations, and to an inability to understand thoroughly and retain abstractions and technicalities of legal documents and government. History should be presented in a manner to appeal to the various interests of the child and should be rich in associations. Enrichment of the curriculum for all children may aid retention.

4. The boys are slightly superior to the girls in retention.

5. Mental age and retention are positively related. Children with higher mental ages need an opportunity for

contact with more of the subject, since they can learn more rapidly and remember more than those having lower mental ages.

6. A negative relationship exists between chronological age and retention. This shows that the oldest pupils in the class room usually forget the most.

7. A positive relationship exists between subject preference and retention. Children who enjoy history are likely to remember more of it than those who do not care for it.

8. Interest and effort and retention, reading comprehension and retention show a positive relationship. Leading a child to really understand what he is reading aids retention.

9. The evidence of this investigation indicates that there are no significant grade variations in the retention of history. Greater variation is found between different groups within a single grade than between different grades.

J. A. Cederstrom[8] (1930) of the University of Minnesota investigated the retention of information gained in courses in zoology at the college level. Two range-of-information scales in zoology were the instruments of measurement. These tests were given at the beginning of the course, at the end, and one year later. Two groups of students at the university served as the subjects of the investigation:

8. Cederstrom, J. A. : Retention of Information Gained in Courses in Zoology. Pedagogical Seminary 38:516- 520, December, 1930

1 The academic group pursuing the study as an elective-31 cases with complete records.

2. The pre-medical and pre-dental group pursuing the study as a required prerequisite-56 cases with complete records. While both men and women were represented in the study, women were in the minority in the larger group, constituting less than 10 per cent. of the group; in the smaller group there were thirteen women and eighteen men. To forestall any review on the part of the students previous to the test a year after the completion of the course, the academic group was called together by the Dean, the purpose of the gathering being unannounced. The pre-medical and pre-dental group were tested through the cooperation of the chemistry department since they were all taking a required course in chemistry.

The data reveal the superiority of the women over the men with respect to retention and to the amount of gain. This may be due to difference in attitude in learning, difference in selection, or to the unreliability of the mean per cent. owing to the small number of cases. Retention scores represent the difference between the initial scores and the scores made by the same students one year later. The gains are expressed in terms of the differences between the scores on the initial and the final measurement at the completion of the course.

The experimenter summarizes his findings as follows:

1. After a year students retain from .6 to .8 as much as they gained during the work of the course.

2. The women, a more highly selected group than the men, tend toward better retention than the men.

3. The percentage of retention seems to be but slightly related to the percentile ratings on the college aptitude test, while the amounts retained seem to be related to the ratings on the college aptitude test only to a small extent.

4. The amounts of retention are proportionate to the amounts of gain.

It is commonly said that motor habits deteriorate less with the lapse of time than do associations between words or other symbols. Is this difference in retention due to the fact that one habit is motor and the other ideational or at least that the overt movements are more prominent in the one than in the other activity ? Or is the difference due rather to the structure of the forms of learning which are compared ? Motor learning might consist of a small number of operations repeated over and over again, while ideational learning consisted of a large number of operations, each one of which was repeated less often. With a view to determining answers to these questions F. N. Freeman and E. M. Abernethy [9] (1930) undertook an investigation in the field of typewriting.

The 50 young women subjects were ~~divided~~ divided into two groups of 25 each approximately equal on the basis of mental test scores as determined by the Terman Group Test. All were members of college classes in psychology. None was familiar with the typewriter keyboard. The first group, the motor learning

9.Freeman, F. N. and E. M. Abernethy : Comparative Retention of Typewriting and of Substitution with Analogous Material. Journal of Educational Psychology 21:039-047, December, 1930.

group, learned to typewrite a short paragraph containing every letter of the alphabet with the keys covered with blank caps and a drawing of the keyboard placed in the view of the learner. The second or substitution group translated the same paragraph into digits following a key containing the letters of the alphabet and corresponding numbers placed before the learner. Each individual worked in practice periods approximately 50 minutes in length until the material was learned to the point of two successive correct repetitions without the use of the diagram. The same number of associations was learned in each task. Hence there was no more overlearning in one case than in the other. The typewriting group required more time and a larger number of trials to learn the material than the substitution group. Two weeks after the completion of the original learning the first relearning took place, and the second relearning occurred eight weeks after the first relearning.

The results of the experiment showed that for the substitution group the loss which began during the first two weeks continued during the succeeding eight weeks. For the typewriting group, although a loss comparable to that of the substitution group was evident during the first two weeks, there was some gain during the last eight weeks. On the basis of these results it may be concluded that, for the types of learning studied, the existence of overt movements as a part of the learning process makes the effect of the learning more permanent over a ten-week period than when overt movements are not present, although it does not appear to affect the performance over the shorter period of two weeks.

The permanence of learning in elememtary botany was investigated by P. O. Johnson [10.] (1930) of the University of Minnesota. The purpose of this study was two-fold:

1. To determine the extent of retention of botanical information acquired by certain students in the course in general botany at the university.

2. To determine the relationship between the amount of information retained and the initial amount possessed.

During the year 1926-1927, an objective final examination was given to all students in general botany at the end of each quarter's work. Accordingly there were three final objective examinations covering the content of the course. From an aggregate of 587 items, 126 true-false and 172 completion were selected and arranged in order of difficulty as determined by frequency of error. This constituted the retention test. In the fall of 1927, 93 former students of botany at the University of Minnesota took this test. Intervals of three, fifteen, and twenty-seven months had elapsed from the time the course in elementary botany was completed until the time of the test. It was also given to 126 students entering upon the course in general botany.

Careful study of the data shows that students who have the most botanical information (as measured by the botany test) at the time of completing the course in general botany are likely to

10. Johnson, P. O. : The Permanence of Learning in Elementary Botany. Journal of Educational Psychology 21:37-47, January 1930.

retain not only absolutely but also relatively more of this information after a lapse of six or three months in time. The amount of botanical information possessed upon entering the course was insignificant.

A. G. Dietze and G. E. Jones [11.] (1931) conducted in Uniontown, Pennsylvania, and its environs an experiment to determine the factual memory of secondary school pupils for a short article which they read a single time. The subjects of the experiment were 2789 children in grades 7 through 12. Three interesting and highly factual articles approximately equal in length were each printed in pamphlet form under the titles "Radium - the Magic Metal ", "The Early Germans", and "Sir Richard Arkwright". Objective tests on the content of each article were given at intervals of 1, 14, 30, and 100 days. The resulting data gave rise to the following conclusions:

1. Immediate and delayed factual memory for an article read a single time varies with the material used, the more familiar article being remembered better than the less familiar.

2. Wide individual differences are present in the abilities of subjects to remember what they read a single time.

3. Immediate memory and one day delayed memory for an article read a single time increases with grade level from the

11. Dietze, A. G. and G. E. Jones : Factual Memory of Secondary School Pupils for a Short Article Which They Read a Single Time. Journal of Educational Psychology 22:586-598,607-076, November and December, 1931.

seventh through the twelfth grades. But no marked relation exists between grade and factual memory over 14 days and longer.

4. Factual material is forgotten rapidly at first, then more and more slowly as the interval between the learning and the measure of memory increases.

5. The point of complete forgetting is not nearly approximated even after 100 days.

6. An appreciable amount of material is forgotten during the time of reading and writing the test.

These conclusions have a definite bearing upon the study habits of secondary school pupils. A single reading of the lesson assignment is an inefficient method of study. Repeated readings, summarizing, reading to find answers to questions and to solve problems, all may aid in eliminating present difficulties. However further research is needed to determine the factors inherent in the material read and in the mental makeup of pupils which determine the efficiency of memory.

The retention of information learned in college courses was considered by Edward B. Greene [12.] (1931) of the University of Michigan. The courses dealt with, included elementary courses in zoology and psychology and an advanced course in physiological chemistry. The results on the objective tests showed that in October students have lost approximately one

12. Greene, E. B. : The Retention of Information learned in College Courses. Journal of Educational Research 24:262-273, November, 1931.

half of the information which they reported correctly on the June examinations. High school courses contribute but little to the standing of those who have taken them, for they do work only slightly superior to that of those who have had no previous formal training.

A recent study of the permanence of learning at the secondary school level is that made by Edna H. Layton [13.] (1932) in the field of elementary algebra. This investigation was carried on in the Milne High School, Albany, the practice school for New York State College for Teachers. The experiment subjects were 51 ninth year pupils, 39 girls and 12 boys, ranging in I. Q.'s from 90 to 128, with a median of 114. The experimental test used was the New York State Regents' Examination for August, 1928. Part I dealt with manipulative techniques and Part II with problems. The test was first given in May, 1929, following the completion of the last new work to be presented in the course. It was repeated after one month of intensive review in June, 1929. A year elapsed before the next time of testing, during which interval no child in the group received any instruction whatsoever in any branch of mathematics. There was no reason to suppose that any review took place, for the children were not told that the test was to be repeated in May, 1930. The following significant conclusions were among those derived from the investigation:

13. Layton, E. H. : The Persistence of Learning in Elementary Algebra.
Journal of Educational Psychology 23:46-55, January, 1932.

1. Pupils retain about one third of the knowledge of elementary algebra, once known, over a period of one year during which they receive no instruction in mathematics.

2. Girls tend to retain better than boys, but the number of cases available is too small for any generalization to be made.

3. There is some evidence that the ranking of pupils according to I. Q.'s and ranking according to the amount of knowledge retained tend to be similar.

4. Pupils tend to retain best a knowledge of factoring, substitution, verbal problems, finding an average, number problems involving integers and those with fractions, and the construction of graphs.

5. Pupils do not retain a knowledge of the manipulation of fractions and fractional equations, of the solution of quadratic equations that have even answers and those which are solved correctly to a decimal place, of square roots, of the solution of simultaneous quadratic equations, of the solution of measurement problems.

These studies, varied as they are with regard to content and grade level, indicate the complexity of the problem of retention and the continued necessity for further experimentation in school subjects. Its implications are too important for it to remain unheeded. The results of scientific investigation in retention should influence future educational policies and procedures.

## Chapter II.

## The Newport Experiment.

To find out the extent of retention of general science knowledge by unselected ninth grade pupils in the senior high school, an investigation was conducted by the writer at the Rogers High School, Newport, Rhode Island. This was made possible only through the whole-hearted cooperation of Mr. Frank M. Greenlaw, the head of the science department of the school, and by members of the department.

The specific objectives of this investigation are suggested by the following questions:

SPECIFIC OBJECTIVES.

1. What is the influence of sex on retention ? Do boys and girls compare favorably with respect to the retention of general science knowledge ? Or is one group markedly superior to the other ? Tradition would concede superiority to the boys, but does the present school population follow tradition ?

2. What is the influence of mental age on retention ?

Granted that those mentally superior pupils will in all probability learn more than their mental inferiors, do they retain what they learn to a greater degree ? Is there a positive relationship between mental age and retention ?

3. What is the influence of chronological age on retention ?

Does any relationship exist between chronological age and retentive ability in general science ? Do the oldest

pupils retain the least and the youngest pupils the most ? Or are the two factors apparently unrelated ?

4. Do pupils interested in science remember more than those less interested ?

It may be expected that those pupils who express a liking for the subject will retain their knowledge better than those less interested in the subject. Does the evidence furnished by this study support this point of view ?

5. What types of general science knowledge tend to be retained and what forgotten ?

Do any specific branches of science tend to be retained to a greater degree than others ? After an interval of time are pupils able to apply the scientific principles that have been presented to them ? Or is retention confined to factual material ?

The necessary data for this study were obtained by selecting as experimental subjects six divisions of ninth grade pupils enrolled in general science. These pupils were taught by four teachers-three men and one woman. One man-teacher and the woman had two divisions each, and the remaining two men, one division each.

THE SELECTION OF THE PUPILS.

The pupils themselves represent an entirely unselected group. Included in the study are 144 pupils, of which number 84 are girls and 60 boys. At the outset, in January, 1931,

166 pupils were enrolled in these science classes. But 22 had to be excluded before the completion of the investigation, because they were absent from school at the time the test was given or because they were eliminated from school before June, 1931 for various reasons. All were classified as freshmen in the Rogers High School of Newport, Rhode Island. With few exceptions they entered high school from the eighth grade of the grammar school. They had had no experience in departmental methods.

Table I. shows the grouping of these pupils by curricula.

Table I.

Distribution of 144 Pupils by Curricula.

| Curriculum | Girls Number | Girls % | Boys Number | Boys % | Total Number | Total % |
|---|---|---|---|---|---|---|
| Commercial | 58 | 69.1 | 18 | 30.0 | 76 | 52.8 |
| Scientific | 0 | 0 | 29 | 48.3 | 29 | 20.1 |
| General | 18 | 21.4 | 10 | 16.7 | 28 | 19.4 |
| Classical | 3 | 3.5 | 3 | 5.0 | 6 | 4.2 |
| Normal | 5 | 6.0 | | | 5 | 3.5 |
| | 84 | 100.0 | 60 | 100.0 | 144 | 100.0 |

The fact that general science is required in both the commercial and the scientific curricula accounts for the ranking of these two groups. It is elective for the general, classical, and normal pupils. No curricular group is segregated in any single science class; assignment to a division is made solely on the basis of schedule convenience.

The chronological ages of these 144 pupils present a wide distribution. The youngest, a girl, is twelve years and seven months while the oldest, a boy, is eighteen years and six months. For the boys the median age is fourteen years

nine months; the median age for the girls is fourteen years ten months. The modal ages also show a variation of one month, that for the boys being fourteen years six months, while that for the girls is fourteen years seven months. The ages of the boys range from twelve years eight months to eighteen years six months; the girls' ages range from twelve years seven months to eighteen years three months.

A study of the mental ages of the group shows an equally wide range. For the group as a whole the limits of distribution are from eleven years five months to eighteen years nine months. The boys are slightly superior mentally to the girls. The mental ages for the boys range from twelve years four months to eighteen years nine months. The girls mental ages fall between the limits of eleven years five months and seventeen years nine months. The median mental age for the boys is fifteen years four months, while that for the girls is fourteen years six months. A comparison of modal mental ages reveals a difference of a year. That for the boys is fifteen years; that for the girls, sixteen years.

An expression of subject preference was secured by asking the pupils to list in order, beginning with the subject they liked the best, the subjects they were taking. They were informed that this ranking would in no way predetermine or influence their standing. In this way an attempt was made to secure an honest expression of opinion.

Table II is a summary of the rank given to general science.

Table II.

Preference of 144 Pupils for General Science.

| Choice | Girls Number | Girls % | Boys Number | Boys % | Total Number | Total % |
|---|---|---|---|---|---|---|
| 1. | 26 | 31.0 | 30 | 50.0 | 56 | 38.9 |
| 2. | 29 | 34.5 | 24 | 40.0 | 53 | 36.8 |
| 3. | 25 | 29.7 | 6 | 10.0 | 31 | 21.5 |
| 4. | 3 | 3.6 | | | 3 | 2.1 |
| 5. | 1 | 1.2 | | | 1 | 0.7 |
| | 84 | 100.0 | 60 | 100.0 | 144 | 100.0 |

It is hardly surprising to find that 50% of the boys place general science in first place. According to tradition boys should like general science better than girls. The group as a whole likes science, for approximately 70% place it in first and second rank, first place leading by a small margin.

Possibly ranking would differ if not taken by a general science teacher. To check the results of this ranking all freshmen enrolled in 1931-1932 were asked by their home room teachers to rank the subjects they were taking in order of preference. In this way it was hoped to obtain an expression of opinion unbiased, in so far as possible, by the personality of the subject teacher and the atmosphere of the class room. Table III summarizes the ranking of general science by 230 freshmen.

Table III.

Preference of 230 Pupils for General Science

| Choice | Girls Number | Girls % | Boys Number | Boys % | Total Number | Total % |
|---|---|---|---|---|---|---|
| 1. | 28 | 20.7 | 49 | 51.6 | 77 | 33.5 |
| 2. | 26 | 19.3 | 29 | 30.5 | 55 | 23.9 |
| 3. | 29 | 21.5 | 10 | 10.5 | 39 | 17.0 |
| 4. | 34 | 25.2 | 4 | 4.2 | 38 | 16.5 |
| 5. | 18 | 13.3 | 3 | 3.2 | 21 | 9.1 |
| | 135 | 100.0 | 95 | 100.0 | 230 | 100.0 |

On the basis of this evidence it seems that at least 50 per cent. of those taking general science like it sufficiently well to give it first or second place when all the subjects being studied are ranked in order of preference. In 1931-1932 fewer girls express a preference for the subject than in 1930-1931. It is their ranking that pulls down the total average. It is to be noted that in 1931-1932 a slightly larger per cent. of boys place science first than in 1930-1931. In both years first place leads in the ranking. Hence it may be assumed that the typical group of high school freshmen enjoy the study of general science.

The initial test was given to all the pupils in general science at their semester examination in January, 1931. The six divisions selected for this investigation were ADMINISTRATION. re-tested by using the same test six weeks later. The third time of testing was twelve weeks after the second, or eighteen weeks after the initial examination. The pupils were not forewarned that the test

was to be repeated, hence there is little reason to suppose that any review took place. It must be remembered that during the eighteen-week interval the work being pursued was that of the second semester. The time of the pupils was fully occupied with advance material.

The tests were supervised by the class teachers. After the children filled in the blanks on the cover page, they were instructed to read the directions at the beginning of Part I carefully and then to proceed with the test at their own rates.

No definite time limit was set. The test subjects were neither rushed nor unduly excited. During the semester, objective tests were given at frequent intervals. Hence the children were thoroughly familiar with the form of the test and the most efficient method of attack. In all but a few isolated cases the test was completed with but few omissions in either section. What omissions did occur were very evidently due to lack of knowledge rather than to lack of time. None of the children requested more time and many finished before the end of the class period.

Although no definite expression of opinion is available, the writer believes that on the whole the children liked the test. Fully 50% of them voiced approval verbally. The type appeals to them because it is fair, it is easily and quickly done with a minimum expenditure of physical energy.

## Chapter III.

## The Retention Test

The retention test used in this investigation was an old examination in general science, devised by members of the science department of the Rogers High School. To suit the purposes of the investigation its form was slightly modified by the experimenter. It was based upon the material presented in the first half year of the general science course. The major topics covered are:

CONSTRUCTION OF THE RETENTION TEST .

I. Air and how we use it.
   a. Air and air pressure.
   b. Air and fire.
   c. Air and breathing.
   d. Air and health.

II. Water and how we use it.
   a. Water in our homes.
   b. The weather.

These topics are not reconsidered or further developed in the subject matter covered during the second semester. The major divisions of material studied during that interval include:

I. Heating our homes.

II. Lighting our homes.

III. Foods and how we use them.

a. Food in the home.

b. Food-its use and composition.

c. Food and the human body.

d. Plants-the food-makers for the world.

All classes used the same text-book, namely "The Science of Everyday Life" by Van Buskirk and Smith, published by Houghton Mifflin Company, 1925.

In the construction of the test an attempt was made to present a well-balanced sampling of the six fields of knowledge dealt with in the classroom. Forty multiple-choice items and forty true-false statements comprise the test. Their distribution among the topics covered is shown by Table IV:

Table IV.

Topical Distribution of 80 Retention Test Items.

| Field | Part I. (multiple-choice) | Part II (true-false) | Total |
|---|---|---|---|
| Air and air pressure | 7 | 12 | 19 |
| Air and fire | 8 | 2 | 10 |
| Air and breathing | 4 | 7 | 11 |
| Air and health | 8 | 8 | 16 |
| Water in our houses | 8 | 5 | 13 |
| The weather | 5 | 6 | 11 |
| | 40 | 40 | 80 |

No attempt was made to arrange the items in order of difficulty. Some items so easy that they could be answered correctly by all the pupils were included. A few questions were deemed so difficult that they would challenge the best minds in the group and would be answered correctly only by

children of superior ability.

For each of the forty multiple-choice items in Part I, five choices are given. It was considered advisable to have the correct choices distributed approximately equally in each of the five places. Hence seven of the correct choices are 1's, nine 2's, seven 3's, eight 4's, and nine 5's. The wording was such that only one answer was acceptable.

In Part II, that section composed of forty true-false statements, twenty-one items are true and nineteen are false. These are not arranged in any fixed order. In phrasing these statements attention was given to the vocabulary used since "specific determiners", "catch" words and phrases, and unfamiliar words were to be avoided.[1]

The four mimeographed sheets comprising the test were bound together. The first or cover page provided space for name, date, age in years and months, section, teacher, home room, and numbered blanks in which the pupil was to indicate the order of preference of the subjects he was taking. At the beginning of Part I, adequate directions for answering the multiple-choice items were given. The number of the correct word or phrase, not the word or phrase itself, was to be placed in the blank provided on the right-hand margin of the page. One sample was given. Adequate directions were also provided for Part II, with two samples given, one true and the other false. The pupils were directed to place in the blank at the left of each item

1. Ruch, G. M. : The Objective or New Type Examination, p.268.

a plus (+) sign or a zero (0) to indicate whether the item were true or false. This system of notation was used in preference to the plus and minus sign system in order that no question should arise with regard to signs written carelessly.

It has already been stated that 40 multiple-choice and 40 true-false items comprise the test. These are reproduced on the pages that follow, together with the detailed directions given to the pupils.

THE RETENTION TEST USED.

General Science I B.

Name: Teacher:

Date: Section: Home room:

Age: Years_____ months _____ Grade:

List below the subjects you are taking. On the first line write the one that you like best. On the second line write the one that you like next best, and so forth.

1.----------

2.----------

3.----------

4.----------

5.----------

Part I.

Directions: Below are 40 incomplete statements. Five words or phrases are given after each statement. One of these five words or phrases makes the statement true; the other four are incorrect.

Read each statement carefully, decide which of the five possible words or phrases makes the truest sentence, then write the NUMBER (not the word or phrase itself) on the line at the right, as shown in the sample:

Sample: The blood is pumped by the (1) liver (2) lungs (3) stomach (4) veins (5) heart. 5

BEGIN HERE:-

1. An example of a chemical element is (1) water (2) carbon dioxide (3) mercury (4) ammonia (5) nitric acid. _____
2. When carbon dioxide is passed through lime water, the liquid (1) remains clear (2) becomes cold (3) turns red (4) becomes cloudy (5) expands greatly. _____
3. A cubic inch of water if allowed to freeze will form (1) less than a cubic inch of ice (2) more than a pint of ice (3) exactly a cubic inch of ice (4) sometimes more and sometimes less than a cubic inch of ice (5) more than a cubic inch of ice. _____

4. Water can be decomposed into its elements by (1) evaporation (2) freezing (3) boiling (4) hydrolysis (5) electrolysis. ____
5. Increasing the relative humidity of the air of a room makes the room seem warmer because (1) it cleanses the pores (2) it decreases the rate of evaporation (3) more heat is needed to dry the room (4) persons move around more to keep warm (5) it increases the rate of evaporation. ____
6. A number of cells of the same kind that do the same work is called a (n) (1) mass (2) organ (3) tissue (4) plasma (5) epidermis. ____
7. The electrolysis of water liberates hydrogen and (1) sulphur dioxide (2) carbon dioxide (3) ammonia (4) nitrogen (5) oxygen. ____
8. Nitrogen in the air (1) aids burning (2) dilutes the oxygen (3) is food for animals (4) combines with carbon dioxide (5) is poisonous to man. ____
9. Contaminated water can be rendered safe to drink by (1) simple filteration (2) exposure to sunlight (3) sedimentation (4) aeration (5) treatment with chlorine. ____
10. When a liquid contains the maximum amount of a dissolved substance possible, its condition is called (1) osmosis (2) permeability (3) fusion (4) saturated (5) aerated. ____
11. When unconfined air is heated, it (1) contracts (2) falls (3) evaporates (4) liquifies (5) expands. ____
12. A rising barometer indicates the approach of (1) clear weather (2) a storm (3) cloudy weather (4) a warm wave (5) a cold wave. ____
13. The body is not crushed by the pressure of the air because (1) the body is strong enough to resist this pressure (2) we are accustomed to the pressure and do not notice it (3) the pressure is exerted equally in all directions (4) the pressure from within the body is equal to the pressure on the outside (5) the muscles prevent it. ____
14. If all the air were pumped out of a metal tube whose area of cross section is one square inch, in order to remove your hand which is covering one end, you would have to pull with a force of about (1) 8 pounds (2) 15 pounds (3) 45 pounds (4) 60 pounds (5) 13.6 pounds. ____
15. Water cannot be siphoned out of a boat which is in the water because (1) there is more water outside the boat than inside (2) there is an attraction of water particles for each other (3) there is suction (4) the side of the boat is too high (5) the level of the water in the boat is too low. ____

16. Pressure of water at any faucet connected to a stand pipe is dependent upon the (1) diffusion (2) volume of water (3) depth of water (4) friction in the pipe (5) material of which the pipe is made. _____

17. The separation of liquids from dissolved solids by evaporation and condensation is called (1) diffusion (2) transpiration (3) solution (4) distillation (5) pasteurization. _____

18. To prevent sewer gases from entering the house, drain pipes are connected to plumbing fixtures by (1) water traps (2) iron bolts (3) condensers (4)leather washers (5) faucets. _____

19. The ordinary house fly is dangerous because it (1) destroys crops (2) has a poisonous bite (3) carries bacteria (4) buzzes (5) is hard to strike. _____

20. Bacteria cause (1) typhoid fever (2) high blood pressure (3) low blood pressure (4) indigestion (5) diabetes. _____

21. Pneumonia is a disease of the (1) heart (2) lungs (3) kidneys (4) stomach (5) intestines. _____

22. Carbon dioxide is an effective material with which to extinguish a fire because (1) it is cheap (2) it is easily liquified (3) it is easily compressed (4) it is easy to make (5) it will not burn. _____

23. Water pipes sometimes burst in winter (1) because water expands when it freezes (2) because lead pipes contract when cooled (3) because the lead expands (4) because of chemical action (5) because of brittleness. _____

24. In a hot water tank the hotter water is found at the top of the tank because (1) heated bodies tend to rise (2) hot water weighs less than an equal volume of cold water (3) steam pressure forces it to the top (4) the tank is lower than the hot water faucet (5) it is heated there. _____

25. A general term for any living thing is (1) a cell (2) a plant (3) an animal (4) an organism (5) protoplasm. _____

26. Persons suffering from scarlet fever are quarantined (1) to protect the patient (2) to make money (3) to prevent the spread of the disease (4) to satisfy public opinion (5) to keep the patient at home. _____

27. Precipitation of water vapor from the air will take place when (1) the temperature rises (2) the wind begins to blow (3) the barometer shows a high pressure (4) the temperature falls below the dew point (5) the amount of evaporation is increased. _____

28. Relative humidity refers to (1) the proportionate amount of water vapor in the air (2) the weight of water vapor in the air (3) the condensation of water (4) the temperature at which dew forms (5) the evaporation of water. _____

29. When oxidation produces a marked rise in temperature or a visible flame, it is called (1) medium (2) slow (3) rapid (4) spontaneous (5) instantaneous. _____

30. When oxygen combines with some other substance, the process is called (1) electrolysis (2) oxidation (3) reduction (4) freezing (5) boiling. _____

31. The greatest vertical height to which water can be lifted by a lift pump is about (1) 30 feet (2) 30 inches (3) 10 feet (4) 100 yards (5) 1 mile.

32. The mercurial barometer at sea level reads about (1) 100 inches (2) 30 centimeters (3) 30 inches (4) 700 inches (5) 30 feet. _____

33. Air is (1) a compound substance (2) a mixture of elements (3) only a single element (4) a mixture of compounds and elements (5) a mixture of compounds only. _____

34. The boiling point of water on the Centigrade scale is (1) 0° (2) 100° (3) 212° (4) 32° (5) 98.6°. _____

35. The part of the air which supports combustion is (1) oxygen (2) nitrogen (3) carbon dioxide (4) helium (5) water vapor. _____

36. A gas which is present in pure air in very small amounts but which is present in larger amounts in air exhaled from the lungs is (1) nitrogen (2) oxygen (3) argon (4) helium (5) carbon dioxide. _____

37. A violent circular windstorm of small area is a (n) (1) cyclone (2) tornado (3) monsoon (4) anticyclone (5) equinox. _____

38. Isotherms on weather maps are used in recording (1) magnetism (2) temperature (3) atmospheric pressure (4) humidity (5) gravitation. _____

39. The material which forms the basis of life is (1) plasma (2) endosperm (3) haemoglobin (4) cell walls (5) protoplasm. _____

40. Of the following devices the one which does not use up the oxygen of the air in a room is (1) a candle (2) a gas range (3) a kerosene lamp (4) an electric stove (5) an oil stove. _____

## Part II.

Directions: Below are 40 true-false statements. About one half of them are true and about one half are false. Read each statement carefully. If you think it is true, place + in the space at the left. If you think it is false place 0 in the space at the left. Think carefully. Do not guess!

Samples: + 1. The blood is pumped by the heart.
0 2. Sugar is produced in mines.

BEGIN HERE:

____1. Under normal conditions air is a liquid.

____2. Air may be compressed.

____3. Air in places of public assembly always contains bacteria.

____4. All bacteria are harmful.

____5. Most bacteria die soon in sunlight.

____6. Exercise does not increase the rate of breathing.

____7. Water is a compound.

____8. Carbon dioxide is not heavier than air.

____9. The water that gathers on the outside of a glass tumbler containing ice water comes from the water in the tumbler.

____10. A single bacterium cannot be seen with the naked eye.

____11. The Eustachian tube is a part of the nose.

____12. A bicycle pump is an example of a compression pump.

____13. An aneroid barometer contains no liquid.

____14. Sound and light travel at the same speed.

____15. Sound is a vibration.

____16. Sulphuric acid is a compound.

____17. All substances ignite at the same temperature.

____18. The normal rate of breathing per minute is approximately 72.

____19. Air exerts pressure downwards but not upwards.

_____ 20. Wind is air in motion.

_____ 21. The freezing of water is a chemical change.

_____ 22. Bacteria reproduce rapidly.

_____ 23. Typhoid fever is a disease often spread by impure drinking water.

_____ 24. It takes the same length of time to boil an egg on a high mountain as it does to boil it at the sea-shore.

_____ 25. Hot water is heavier than cold water.

_____ 26. Air in well-ventilated rooms should be in motion.

_____ 27. Fishes breathe by means of lungs.

_____ 28. The boiling point on the Fahrenheit thermoneter is 100.

_____ 29. Water exerts equal pressure in all directions.

_____ 30. Humidity refers to the amount of oxygen in the air.

_____ 31. Warm air has a greater capacity for water vapor than cold air.

_____ 32. On the weather maps the isobars indicate the amount of rainfall.

_____ 33. Sound cannot travel through a vacuum.

_____ 34. Common colds are caused by bacteria.

_____ 35. Steam is water vapor at the boiling point.

_____ 36. The dew point is the temperature at which ice crystals begin to form.

_____ 37. The pressure of air at sea level is approximately 15 pounds per square inch.

_____ 38. The Weather Bureau is conducted by the Department of Agriculture.

_____ 39. The white corpuscles of the blood carry oxygen to the body cells.

_____ 40. Robert Koch discovered the bacteria that cause tuberculosis.

## Chapter IV.

## The Amount Of Retention In General Science.

To find out the extent of retention of general science knowledge by ninth grade pupils in the senior high school, the test described in a previous chapter was given to 144 pupils at the Rogers High School, Newport, Rhode Island. This test was repeated at intervals of six and eighteen weeks after the initial time of testing. The pupils were divided into six divisions taught by four different teachers.

The results on these tests were tabulated by the experimenter on the basis of the number of errors that occurred.

ATTACK OF THE PROBLEM.

Hence the problem has been approached from the negative view-point rather than the positive. In interpreting the data it must be remembered, then, that unless otherwise stated, the figures refer to numbers of errors. A small amount of forgetting means a large amount of retention; similarly a large amount of forgetting means a small amount of retention.. The maximum score obtainable on any trial was 80.

The data obtained as a result of the first testing are indicative of the amount of general science knowledge gained during the course. The results on the second and third testing indicate the amount of such knowledge retained. Throughout this study medians rather than means have been dealt with, since extreme scores have less effect upon the first measure of central tendency than upon the second.

An examination of the data shows that the median number of

errors made by the pupils immediately after they have finished the semester's work in science is 18.7. On the second trial we find a slight increase to 21.25. This standing is practically maintained on the third test, for the median number of errors is found to be 21.75. This indicates that the maximum amount of forgetting for the group as a whole occurs in the six-week interval with practically no loss in the twelve-week period that follows. The rate of forgetting is materially decreased during the second interval, which, it must be noted, is twice as long as the first. This evidence supports the theory that forgetting occurs most rapidly at first and then decreases in rate with an increase in time.

MEDIAN LOSSES

The range of errors made by 144 pupils shows a wide distribution. On the initial test, $T_0$[1], the minimum number was 2 and the maximum 47. Trial II, ($T_6$), shows a spread of 1 to 39, while Trial III, ($T_{18}$), yields a range of 1 to 40. This indicates that some of the pupils learn and retain the major part of the course's content, while others learn and retain but little more than 50 per cent.. This is to be expected since the subjects in the experiment were entirely unselected and represent a wide range of mental ability.

What is the relation between sex and retention ? In order to answer this query the data for the 60 boys and the 84 girls were tabulated separately. In each

SEX AND RETENTION

1. $T_0$= Initial test.
   $T_6$= Test after interval of six weeks.
   $T_{18}$= Test after interval of eighteen weeks.

case the median number of errors, the range of errors, and any losses or gains that occurred during the eighteen weeks were found. Table V. summarizes these results.

Table V.

Errors Made by Girls and Boys on Retention Tests.

| | Girls (N=84) | Boys (N=60) |
|---|---|---|
| Median number of errors | | |
| $T_o$* | 22.33 | 14.00 |
| $T_6$ | 24.25 | 14.63 |
| $T_{18}$ | 24.33 | 15.50 |
| Increases or decreases in medians | | |
| $T_o T_6$ | +1.92 | + .63 |
| $T_6 T_{18}$ | + .12 | + .88 |
| $T_o T_{18}$ | +2.00 | +1.50 |
| Range of errors. | | |
| $T_o$ | 4 to 47 | 2 to 41 |
| $T_6$ | 6 to 39 | 1 to 37 |
| $T_{18}$ | 7 to 46 | 1 to 32 |

* $T_o$ = Initial test.
$T_6$ = Test after interval of six weeks.
$T_{18}$ = Test after interval of eighteen weeks.

At a glance these figures indicate that the boys are apparently superior to the girls. They learn more at the outset and they retain more of what they learn over the six week period, and the eighteen week period. This is indicated by the fact that the median number of errors assumes a smaller increment for the boys than for the girls during these intervals. It is to be noted, however, that the rate of forgetting for the boys increases between the second and third times of testing. This is contrary to the generally accepted theory that forgetting occurs rapidly at first and

decreases with the lengthening of time. The situation that exists in the case of these 60 boys may be accounted for, perhaps, by the fact that for boys especially, the content of general science is rich in associations. Material supplementing that presented in the class room arises on every hand and appeals to the interests of the boys. Such material would tend to impress scientific facts upon the young minds and might prolong the period of learning outside of the class room. Hence they would tend to remember much of the content of the science course over an extended period, such as the six week period immediately following the semester's work. The increase in forgetting and the consequent loss in retention between the second and third retests may indicate that for the boys the completion of the initial learning was delayed.

The group of boys in question has a mental age median ten months in advance of the corresponding figure for the girls. This difference in mental ability may account almost wholly for the apparent superiority of the boys. But if we tabulate errors on the basis of mental ages, we find that the boys tend to make fewer mistakes than the girls of the same mental age. Table VI furnishes the mean number of errors made by the pupils grouped according to mental ages . These data indicate that the slight superiority of the boys is actual rather than apparent.

In summarizing, it may be stated that boys are found to

TABLE VI

Mean Numbers of Errors Made by Pupils Grouped by Mental Ages.

| Mental Age† | Girls N. | Girls $T_o$* | Girls $T_6$ | Girls $T_{18}$ | Boys N. | Boys $T_o$ | Boys $T_6$ | Boys $T_{18}$ | Total N. | Total $T_o$ | Total $T_6$ | Total $T_{18}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11-0 to 11-5 | 1 | 24.00 | 23.00 | 26.00 | 0 | -- -- | -- -- | -- -- | 1 | 24.00 | 23.00 | 26.00 |
| 11-6 to 11-11 | 0 | -- -- | -- -- | -- -- | 0 | -- -- | -- -- | -- -- | 0 | -- -- | -- -- | -- -- |
| 12-0 to 12-5 | 6 | 24.83 | 28.67 | 29.33 | 1 | 41.00 | 25.00 | 23.00 | 7 | 27.14 | 28.14 | 28.56 |
| 12-6 to 12-11 | 6 | 24.33 | 27.23 | 27.00 | 1 | 16.00 | 15.00 | 18.00 | 7 | 23.14 | 25.56 | 25.71 |
| 13-0 to 13-5 | 7 | 24.71 | 24.71 | 27.29 | 4 | 24.00 | 24.75 | 21.25 | 11 | 24.45 | 24.73 | 25.09 |
| 13-6 to 13-11 | 8 | 23.63 | 26.00 | 26.75 | 4 | 20.75 | 24.00 | 22.25 | 12 | 22.67 | 25.33 | 25.25 |
| 14-0 to 14-5 | 12 | 22.83 | 25.08 | 25.00 | 5 | 18.00 | 17.80 | 19.40 | 17 | 21.41 | 22.94 | 23.35 |
| 14-6 to 14-11 | 10 | 23.60 | 25.60 | 28.60 | 5 | 16.40 | 17.60 | 18.80 | 15 | 21.20 | 22.93 | 25.33 |
| 15-0 to 15-5 | 10 | 21.90 | 21.90 | 23.20 | 12 | 17.42 | 16.67 | 17.33 | 22 | 19.45 | 19.05 | 20.00 |
| 15-6 to 15-11 | 5 | 20.80 | 19.20 | 23.20 | 6 | 20.33 | 18.17 | 16.67 | 11 | 20.18 | 18.55 | 19.64 |
| 16-0 to 16-5 | 14 | 15.21 | 17.07 | 11.93 | 9 | 14.78 | 14.22 | 15.00 | 23 | 15.04 | 15.96 | 17.48 |
| 16-6 to 16-11 | 1 | 16.00 | 22.00 | 17.00 | 5 | 9.40 | 9.00 | 9.60 | 6 | 10.50 | 11.17 | 10.83 |
| 17-0 to 17-5 | 1 | 9.00 | 9.00 | 11.00 | 5 | 8.00 | 6.40 | 8.40 | 6 | 8.17 | 6.83 | 8.83 |
| 17-6 to 17-11 | 3 | 7.33 | 8.67 | 8.67 | 1 | 14.00 | 9.00 | 9.00 | 4 | 9.00 | 8.75 | 8.75 |
| 18-0 to 18-5 | 0 | -- -- | -- -- | -- -- | 1 | 11.00 | 11.00 | 12.00 | 1 | 11.00 | 11.00 | 12.00 |
| 18-6 to 18-11 | 0 | -- -- | -- -- | -- -- | 1 | 3.00 | 3.00 | 5.00 | 1 | 3.00 | 3.00 | 5.00 |
| | 84 | | | | 60 | | | | 144 | | | |

*$T_o$ = Initial test
$T_6$ = Test after interval of six weeks.
$T_{18}$ = Test after interval of eighteen weeks.

† Mental age as measured by the Otis Self-Administering Test of Mental Ability, Higher Examination, Form A.

be slightly superior to girls in the retention of general science knowledge. They possess more knowledge of the subject at the end of the semester's course and they tend to retain a larger amount of this knowledge than do girls.

MENTAL AGE AND RETENTION.

The mental ages of the 144 boys and girls included in this investigation were determined by giving them the Otis Self-Administering Test of Mental Ability, Higher Examination, Form A. The results on this test were tabulated in order to find the medians. Under each mental age the number of errors made on each test by the individuals included in the group were listed.

The data show that as a group the 60 boys are superior mentally to the 84 girls. Table VII furnishes the medians and ranges for the girls, for the boys, and for the group as a whole.

Table VII.

Mental Ages of 84 Girls and 60 Boys.

| | Girls N = 84 | Boys N = 60 | Total N = 144 |
|---|---|---|---|
| Median | 14 yrs. 6 mos. | 15 yrs. 4 mos. | 15 yrs. |
| Range | | | |
| Minimum | 11 yrs. 5 mos. | 12 yrs. 4 mos. | 11 yrs. 5 mos. |
| Maximum | 17 yrs. 9 mos. | 18 yrs. 9 mos. | 18 yrs. 9 mos. |

It is to be noted that the median mental age of the boys is ten months higher than that of the girls. The girls as a group are practically one year younger mentally than the boys.

Table VIII gives the medians and ranges of the number of

errors made by the upper and lower quartiles of boys, arranged according to mental ages, on the initial test ($T_o$) and on the tests after intervals of six ($T_6$) and eighteen ($T_{18}$) weeks. The upper quartile ($Q_3$) embraces the ages 16 years 5 months to 18 years 9 months; the limits of the lower quartile ($Q_1$) are 12 years 4 months and 14 years 4 months.

Table VIII.

Number of Errors Made By Boys in the Upper and Lower Quartiles of Mental Ages.

| | Median | | Ranges | | | |
|---|---|---|---|---|---|---|
| | | | Minimum | | Maximum | |
| | $Q_3$ | $Q_1$ | $Q_3$ | $Q_1$ | $Q_3$ | $Q_1$ |
| | N=15 | N=15 | N=15 | N=15 | N=15 | N=15 |
| $T_o$* | 9.50 | 20.50 | 2 | 13 | 18 | 41 |
| $T_o$ | 8.20 | 23.50 | 1 | 11 | 14 | 37 |
| $T_{18}$ | 8.80 | 21.25 | 1 | 13 | 17 | 30 |

* $T_o$ = Initial test.
$T_6$ = Test after interval of six weeks.
$T_{18}$ = Test after interval of eighteen weeks.

The median of the upper quartile decreases in the first interval of six weeks. Some relearning must have taken place; the pupils make fewer errors, and they do not lose all of this gain during the succeeding twelve weeks, for at the end of that interval they make fewer errors than they did on the initial test. Those in the lower quartile experience the greatest loss in the first six weeks. During the next twelve weeks some of the lost ground is regained. In both intervals the loss is slight. The evidence indicates that in the case of the boys there is a positive relationship between retention and mental ability.

Those superior mentally learn more and retain more in proportion to what they learn than their not-so-bright class mates. But even in the case of the lower quartile the loss that occurs is slight. Hence it would seem to indicate that teachers of general science should enrich the content of their courses, for what is learned is retained almost in its entirety over a whole semester.

In Table IX the errors made by the upper and lower quartiles of girls are summarized. The mental ages of the girls in the upper quartile range from 15 years 0 months to 17 years 9 months; those in the lower quartile fall between 11 years 5 months and 13 years 7 months.

Table IX.

Number of Errors Made by Girls

in the Upper and Lower Quartiles of Mental Ages.

| | Median | | Range | | | |
|---|---|---|---|---|---|---|
| | | | Minimum | | Maximum | |
| | $Q_3$ N= 21 | $Q_1$ N = 21 | $Q_3$ N= 21 | $Q_1$ N= 21 | $Q_3$ N= 21 | $Q_1$ N= 21 |
| $T_o$* | 13.5 | 24.75 | 4 | 11 | 27 | 47 |
| $T_6$ | 12.5 | 26.75 | 6 | 14 | 29 | 39 |
| $T_{18}$ | 18.25 | 26.66 | 7 | 19 | 34 | 42 |

* $T_o$= Initial test.
$T^o$= Test after interval of six weeks.
$T^o_{18}$=Test after interval of eighteen weeks.

Those girls in the upper quartile gain slightly in the first six weeks, but during the succeeding twelve weeks they lose markedly, since the median number of errors increases 5.75

points during that interval. The loss since the initial test is represented by an increase of 4.75 points in the median number of errors. The lower group suffers a loss during the first six weeks, and then makes a very slight gain during the next twelve weeks. What they know at the end of the semester is largely retained. This evidence seems to indicate that girls of superior mental ability do not retain as much of the general science knowledge as they possessed at the end of the semester as do their companions who are their inferiors mentally. This is the reverse of what is true with the boys. It will be remembered that the superior boys tend to retain more of what they learn than their mental inferiors do.

If the 144 pupils are considered as a group and divided into quartiles, we find that the upper quartile ranges from 16 years to 18 years 9 months. The limits of the lower quartile are 11 years 5 months and 13 years 10 months. Table X shows the median number of errors and the range of errors made by the upper and lower quartiles of pupils arranged in order of mental ability.

Table X.

Number of Errors Made by Pupils

in the Upper and Lower Quartiles of Mental Ages.

| | Median | | Range | | | |
|---|---|---|---|---|---|---|
| | | | Minimum | | Maximum | |
| | $Q_3$ | $Q_1$ | $Q_3$ | $Q_1$ | $Q_3$ | $Q_1$ |
| | N=36 | N=36 | N=36 | N=36 | N=36 | N=36 |
| $T_o$* | 11.42 | 24.50 | 2 | 11 | 30 | 47 |
| $T_6$ | 10.20 | 25.00 | 1 | 11 | 29 | 39 |
| $T_{18}$ | 11.25 | 26.20 | 1 | 13 | 25 | 42 |

*$T_o$ = Initial test.
$T_6$ = Test after interval of six weeks.
$T_{18}$ = Test after interval of eighteen weeks.

It is evident that the upper quartile gains after the initial test. After eighteen weeks this group retains all that it knew at the end of the semester, supplemented by some additional knowledge. The lower quartile suffers a loss during the first six weeks and a further and greater loss during the twelve weeks that follow. The rate of forgetting is more rapid during the second interval than during the first. This is contrary to the usual curve of forgetting.

In summary, these data show in the main a positive relationship between retention and mental ability. The girls of superior mental ability are the only group that does not bear out this statement. They retain less of their original fund of knowledge than their mental inferiors. But their scores are not extreme enough to produce a marked effect on the group as a whole. When the group of 144 pupils is considered, the data show that those in the upper quartile of mental ages retain more in proportion to what they learn than those in the lower quartile. Those in the lower quartile suffer a greater loss. Hence there is evidence of a positive relation between mental age and retention.

CHRONOLOGICAL AGE AND RETENTION.

The boys and girls considered in this investigation range in chronological age from 12 years 7 months to 18 years 6 months. The distribution within these limits approximates the normal curve.

Table XI indicates the medians, modes, and ranges.

Table XI.

Distribution of Chronological Ages.

| | Girls N=84 | Boys N=60 | Total N=144 |
|---|---|---|---|
| Median | 14 yrs. 10 mos. | 14 Yrs. 9 mos. | 14 yrs. 10 mos. |
| Mode | 14 yrs. 7 mos. | 14 yrs. 6 mos. | 14 yrs. 6 mos. |
| Range | | | |
| Minimum | 12 yrs. 7 mos. | 12 yrs. 8 mos. | 12 yrs. 7 mos. |
| Maximum | 18 yrs. 3 mos. | 18 yrs. 6 mos. | 18 yrs. 6 mos. |

In order to determine whether or not any generalization could be made regarding the relationship between chronological age and retentive ability in general science, the errors made by the 144 pupils were tabulated in age groups. Wide limits of error are found in each group. If the modal group, 14 years 6 months is considered, it is found that on Trial I ($T_o$)[2] from 11 to 30 errors are made by the eleven pupils comprising the group. By the same group on Trial II ($T_6$), 9 to 29 errors are made, while on Trial III ($T_{18}$) 9 to 27 errors occur. A pupil aged 12 years 6 months chronologically, the youngest pupil included in the investigation, made 8, 11, and 18 errors on the first, second, and third trials respectively. Another pupil exactly four years the senior of the first made 6, 7, and 9 errors on the three trials respectively. The oldest pupil considered in the study made fewer errors than many of those younger.

Hence no generalization can be made with regard to the relation between chronological age and retention. The evidence

2. $T_o$= Initial test.
$T_6$= Test after interval of six weeks.
$T_{18}$=Test after interval of eighteen weeks.

furnished by this study does not indicate any direct relationship between the two factors. It cannot be said that the oldest pupils retain the least, nor that the youngest pupils retain the most. For as many errors are made by the younger pupils as by those older on the initial test and on the succeeding tests. The increment that the number of errors assumes during the time intervening between successive tests is as large for the younger pupils as for the older. The examples cited above support this statement.

SUBJECT PREFERENCE AND RETENTION.

At the beginning of the investigation each pupil was asked to list in order of preference the school subjects he was taking. That subject which he liked the best was to be placed first, the one liked the next best second, and so on. That subject at the end of the list was to be the one liked the least. Each pupil was urged to be honest in his ranking. That this expression of preference would in no way affect class standing was stressed. The average freshman takes four subjects. But English, required of all, is divided into English Literature and English Essentials. Hence five choices are possible. Table II on page 21 gives the summary of choices. For each "choice" group errors were tabulated for each trial of the test. Medians were computed for each trial, and the positive or negative increments assumed by these medians during the first six weeks, ($T_0T_6$), the succeeding twelve weeks, ($T_6T_{18}$), and the entire eighteen week interval, ($T_0T_{18}$), were found. A positive increment indicates an increase in the median number of errors, while a negative indicates a decrease. Hence a positive

increment means a loss in retention, while a negative means a gain. The summary of these results is given in Tables XII, XIII, and XIV.

Table XII.

Errors Made by 84 Girls Grouped by Subject Choice.

| Choice | 1 N=26 | 2 N=29 | 3 N=25 | 4 N=3 | 5 N=1 |
|---|---|---|---|---|---|
| Median number of errors. | | | | | |
| $T_o$* | 18.00 | 23.25 | 21.25 | 22.50 | 27.00 |
| $T_6$ | 20.50 | 25.25 | 23.83 | 26.50 | 37.00 |
| $T_{18}$ | 22.00 | 26.63 | 23.67 | 23.25 | 31.00 |
| Increases or decreases in medians. | | | | | |
| $T_oT_6$ | +2.50 | +2.00 | +2.58 | +4.00 | +10.00 |
| $T_6T_{18}$ | +1.50 | +1.38 | - .16 | -3.25 | - 6.00 |
| $T_oT_{18}$ | +4.00 | +3.38 | +2.42 | + .75 | + 4.00 |

*$T_o$ = Initial test.
$T_6$ = Test after interval of six weeks.
$T_{18}$ = Test after interval of eighteen weeks.

Table XIII.

Errors Made by 60 Boys Grouped by Subject Choice.

| Choice | 1. N=30 | 2 N=24 | 3 N=6 | 4 N=0 | 5 N=0 |
|---|---|---|---|---|---|
| Median number of errors. | | | | | |
| $T_o$* | 12.00 | 19.00 | 17.50 | | |
| $T_6$ | 11.33 | 19.17 | 14.00 | | |
| $T_{18}$ | 12.00 | 21.25 | 18.00 | | |
| Increases or decreases in medians | | | | | |
| $T_oT_6$ | - .67 | +0.17 | -3.50 | | |
| $T_6T_{18}$ | + .67 | +2.08 | +4.00 | | |
| $T_oT_{18}$ | .00 | +2.25 | +0.50 | | |

*$T_o$ = Initial test.
$T_6$ = Test after interval of six weeks.
$T_{18}$ = Test after interval of eighteen weeks.

Table XIV.

Errors Made by 144 Pupils Grouped by Subject Choice.

| | 1<br>N=56 | 2<br>N=53 | 3<br>N=31 | 4.<br>N=3 | 5<br>N=1 |
|---|---|---|---|---|---|
| Choice | | | | | |
| Median number of errors. | | | | | |
| $T_o$ * | 14.75 | 22.13 | 19.75 | 22.50 | 27.00 |
| $T_6$ | 14.83 | 24.17 | 23.38 | 20.50 | 37.00 |
| $T_{18}$ | 15.75 | 23.50 | 23.25 | 23.25 | 31.00 |
| Increases or decreases in medians. | | | | | |
| $T_oT_6$ | + .08 | + 2.04 | + 3.63 | + 4.00 | +10.00 |
| $T_oT_{18}$ | + .92 | - .67 | - .13 | -3.25 | - 6.00 |
| $T_oT_{18}$ | +1.00 | +1.37 | +3.50 | + .75 | + 4.00 |

*$T_o$ = Initial test.
$T_6$ = Test after interval of six weeks.
$T_{18}$ = Test after interval of eighteen weeks.

A study of these tables shows that those who give general science first rank in preference, that is those who like general science, learn more than those who do not like it so well. They make fewer errors on the initial test. But what of their retention ? Do they retain their knowledge better than those who place science lower in rank ? To answer this question the medians on each retest for each "choice" group must be noted with particular reference to any losses or gains that occur. If the median number of errors is increased, there is a loss of knowledge; if the median number of errors is decreased, there is a gain. That group which shows the smallest amount of increase exhibits the best retention.

Those girls who like general science learn more than those who do not like it so well. As Table XII shows, the greatest loss for all groups occurs during the first six weeks.

During the succeeding twelve weeks the loss continues at a slower rate for the first two groups, while for the remaining three groups some of the ground lost during the first six weeks is recovered. The data show that during the eighteen week period the first group, although it learns more than any of the other groups at the outset, retains less. The increment that the median number of errors assumes during the eighteen week interval grows smaller from the first group to the fourth. In the case of group 5 it is exactly equal to that for group 1, but group 5 is too small for such evidence to have meaning. This indicates that although those girls who do not express a preference for general science learn less in the beginning, they retain more of what they do learn. This may be construed as a negative relationship between subject preference and the retention of general science knowledge.

The boys who placed general science first in rank retained all of their knowledge at the end of eighteen weeks, for the median number of errors on the initial test and on the test given eighteen weeks later is 12. During the first six weeks there was a slight gain. The median of errors is decreased .67. Group 2, comprised of those 24 boys who ranked science second, experienced a loss during the eighteen week interval. The falling off in retention is much more rapid during the last twelve weeks than during the first six. This group learned less than group 1 at the outset and it retained less of what was learned. The six boys in group 3 exhibit better retention than those in group 2. They gain during the first six weeks, and,

although they lose during the next twelve weeks, at the end of the eighteen weeks the median number of errors is only .5 greater than it was on the initial test. This loss is but slight. The amount of retention compares favorably with that of group 1. The number in the group, however, is too small for the results to be considered signigicant. On the basis of this evidence it may be stated that those boys who like general science learn more at the outset and tend to retain that knowledge better than those for whom the subject has less appeal.

If the 144 pupils are considered as a group, the results indicate that those pupils in the first two groups, regardless of sex, tend to retain their knowledge better than those who do not like the subject so well. During the eighteen weeks those in groups 1 and 2 suffer less loss than any other group except group 4. But the small number of individuals in group 4 makes that result of little significance. If the first group is compared with the third, for example, it is noted that the third group suffers the greater loss. Groups 1 and 2 are approximately equal both as to numbers and as to retentive ability. It is to be noted that all groups lose during the first six weeks and that all but group 1 recover some of this loss during the twelve weeks that follow.

Hence the conclusion may be drawn that there tends to be a direct relationship between subject preference and retention. Those pupils who place general science at the beginning of the list tend to retain the subject matter that they learn better than those for whom the subject has less appeal.

## Chapter V.

## A Detailed Analysis of the Retention and Forgetting of General Science Questions.

Of the kinds of general science knowledge that were tested, what kinds of general science knowledge are retained ? What kinds are forgotten ? To answer these questions two methods of attack were used. The first refers to the degree of retention of specific items. The numbers of errors made by the boys and the girls were computed for each of the eighty items of the test for each of the three trials. The results on $T_0$[1] were arranged in order beginning with that item which was answered incorrectly most frequently. The difference between this number and the numbers on the succeeding trials were computed to determine whether there was an increase or a decrease in the number of errors that occurred. Table XV furnishes the number of errors made on $T_0$ for each item, together with the increment that each item assumes during the eighteen week interval. The items are arranged in order beginning with that item which assumes the largest increment. The increment from $T_0$ to $T_{18}$ is significant in this study, for it shows what is retained and what is forgotten during the eighteen week interval. An increase shows that an item was forgotten after the initial test. A zero indicates that the

RETENTION OF SPECIFIC ITEMS.

1. $T_0$ = Initial test.
   $T_6$ = Test after interval of six weeks.
   $T_{18}$ = Test after interval of eighteen weeks.

Table XV.

Increases or Decreases in Numbers of Errors on 80 Test Items Between $T_o$ and $T_{18}$.

| Girls | | | Boys | | | Total | | |
|---|---|---|---|---|---|---|---|---|
| Item | $T_o$ | $T_oT_{18}$ | Item | $T_o$ | $T_oT_{18}$ | Item | $T_o$ | $T_oT_{18}$ |
| 18* | 4 | +45 | 18* | 7 | +28 | 18* | 11 | +73 |
| 32* | 19 | +25 | 12 | 16 | +14 | 32* | 36 | +38 |
| 39* | 31 | +19 | 32* | 17 | +13 | 12 | 58 | +27 |
| 30* | 15 | +16 | 24 | 11 | +10 | 39* | 51 | +23 |
| 32 | 18 | +16 | 13 | 17 | +9 | 30* | 23 | +22 |
| 10 | 11 | +16 | 39 | 27 | +6 | 21* | 59 | +19 |
| 21* | 33 | +14 | 29 | 14 | +6 | 24 | 28 | +18 |
| 12 | 42 | +13 | 30* | 8 | +6 | 28* | 13 | +17 |
| 7* | 11 | +13 | 25 | 42 | +5 | 10 | 18 | +16 |
| 28* | 8 | +13 | 21* | 26 | +5 | 39 | 72 | +15 |
| 38 | 28 | +11 | 39* | 20 | +4 | 36* | 40 | +12 |
| 36* | 28 | +10 | 28* | 5 | +4 | 32 | 26 | +12 |
| 7 | 21 | +10 | 11* | 25 | +3 | 11* | 48 | +11 |
| 39 | 45 | + 9 | 8 | 24 | +3 | 37 | 93 | +9 |
| 33* | 19 | + 9 | 1 | 31 | +2 | 33* | 26 | +9 |
| 6 | 28 | + 8 | 16 | 23 | +2 | 19* | 15 | +9 |
| 11* | 23 | +8 | 36* | 18 | +2 | 13 | 64 | +8 |
| 34 | 22 | +8 | 31* | 19 | +2 | 38 | 50 | +7 |
| 24 | 17 | +8 | 19* | 5 | +2 | 17 | 46 | +7 |
| 19* | 10 | +7 | 22 | 2 | +2 | 31* | 36 | +7 |
| 5 | 58 | +6 | 23 | 1 | +2 | 7* | 27 | +7 |
| 9 | 44 | +6 | 2 | 0 | +2 | 18 | 17 | +7 |
| 17 | 30 | +6 | 23* | 0 | +2 | 8 | 71 | +6 |
| 11 | 28 | +6 | 17 | 16 | +1 | 9 | 52 | +6 |
| 18 | 13 | +6 | 15 | 15 | +1 | 8* | 46 | +5 |
| 15 | 50 | +5 | 28 | 7 | +1 | 34 | 37 | +5 |
| 8* | 31 | +5 | 18 | 4 | +1 | 36 | 14 | +5 |
| 31* | 26 | +5 | 9 | 18 | 0 | 27* | 3 | +5 |
| 36 | 10 | +5 | 8* | 15 | 0 | 29 | 43 | +4 |
| 27* | 9 | +5 | 37* | 11 | 0 | 11 | 38 | +4 |
| 16* | 46 | +4 | 10 | 7 | 0 | 7 | 31 | +4 |
| 25* | 10 | +4 | 33 | 7 | 0 | 28 | 30 | +4 |
| 24* | 7 | +4 | 1* | 6 | 0 | 25* | 12 | +3 |
| 8 | 47 | +3 | 36 | 4 | 0 | 22 | 11 | +3 |
| 29* | 25 | +3 | 9* | 4 | 0 | 23 | 8 | +3 |
| 28 | 23 | +3 | 3 | 3 | 0 | 2* | 3 | +3 |
| 2* | 3 | +3 | 27* | 3 | 0 | 23* | 2 | +3 |
| 35 | 27 | +2 | 31 | 2 | 0 | 6 | 52 | +2 |
| 13* | 21 | +2 | 15 | 1 | 0 | 2 | 0 | +2 |
| 20* | 11 | +2 | 0 | 0 | 0 | 16 | 69 | +1 |
| 6* | 1 | +2 | 37 | 39 | -1 | 29* | 40 | +1 |
| 27 | 56 | +1 | 27 | 30 | -1 | 9 | 20 | +1 |
| 37 | 54 | +1 | 33 | 29 | -1 | 25 | 117 | 0 |
| 14 | 49 | +1 | 20 | 4 | -1 | 5 | 87 | 0 |
| 4 | 28 | +1 | 26 | 2 | -1 | 1 | 74 | 0 |

Table XV (cont.)

| Girls | | | Boys | | | Total | | |
|---|---|---|---|---|---|---|---|---|
| Item | $T_o$ | $T_oT_{18}$ | Item | $T_o$ | $T_oT_{18}$ | Item | $T_o$ | $T_oT_{18}$ |
| 9* | 22 | +1 | 25* | 2 | -1 | 13* | 30 | 0 |
| 22 | 9 | +1 | 19 | 1 | -1 | 1* | 17 | 0 |
| 14* | 9 | +1 | 29* | 15 | -2 | 31 | 12 | 0 |
| 23 | 7 | +1 | 11 | 10 | -2 | 6* | 3 | 0 |
| 23* | 2 | +1 | 13* | 9 | -2 | 27 | 86 | -1 |
| 1* | 11 | 0 | 10* | 5 | -2 | 18* | 81 | -1 |
| 31 | 10 | 0 | 14* | 3 | -2 | 35 | 39 | -1 |
| 10* | 9 | 0 | 6* | 2 | -2 | 20* | 16 | -1 |
| 20 | 2 | 0 | 34 | 15 | -3 | 14 | 12 | -1 |
| 2 | 0 | 0 | 35 | 12 | -3 | 20 | 6 | -1 |
| 19 | 0 | 0 | 4* | 7 | -3 | 15* | 4 | -1 |
| 13 | 47 | -1 | 12* | 7 | -3 | 19 | 1 | -1 |
| 16 | 46 | -1 | 20* | 5 | -3 | 37* | 43 | -2 |
| 34* | 24 | -1 | 40 | 4 | -3 | 24* | 16 | -2 |
| 4* | 13 | -1 | 22* | 4 | -3 | 10* | 14 | -2 |
| 17* | 8 | -1 | 26* | 3 | -3 | 26 | 4 | -2 |
| 3* | 4 | -1 | 38 | 22 | -4 | 3 | 21 | -3 |
| 15* | 3 | -1 | 32 | 8 | -4 | 14 | 75 | -4 |
| 26 | 2 | -1 | 3* | 7 | -4 | 4* | 20 | -4 |
| 1 | 43 | -2 | 30 | 4 | -4 | 17* | 12 | -5 |
| 37* | 32 | -2 | 17* | 4 | -4 | 3* | 11 | -5 |
| 29 | 29 | -2 | 16* | 35 | -5 | 33* | 60 | -6 |
| 30 | 14 | -2 | 14 | 26 | -5 | 4 | 40 | -6 |
| 26* | 15 | -3 | 35* | 23 | -5 | 30 | 18 | -6 |
| 12* | 14 | -3 | 38* | 9 | -5 | 26* | 18 | -6 |
| 3 | 19 | -4 | 21 | 7 | -5 | 40 | 22 | -7 |
| 40 | 18 | -4 | 5 | 29 | -6 | 22* | 11 | -7 |
| 22* | 7 | -4 | 6 | 24 | -6 | 34* | 46 | -9 |
| 25 | 75 | -5 | 7* | 16 | -6 | 15 | 65 | -10 |
| 33 | 31 | -5 | 7 | 10 | -6 | 35* | 46 | -12 |
| 35* | 23 | -5 | 24* | 9 | -6 | 21 | 21 | -12 |
| 21 | 14 | -7 | 4 | 12 | -7 | 26 | 4 | -12 |
| 40* | 26 | -9 | 34 | 22 | -8 | 38* | 36 | -12 |
| 38* | 27 | -16 | 5* | 20 | -9 | 40* | 47 | -25 |
| 5* | 29 | -22 | 40* | 21 | -16 | 5 | 49 | -31 |

* = true-false statements.

$T_o$ = initial test.

$T_oT_{18}$ = interval of eighteen weeks.

number of errors remained constant. A decrease shows that that particular response was relearned during the interval and was answered correctly at the end of eighteen weeks by a larger number than on the initial test. This indicates good retention.

In Part I, the multiple-choice section of the test, the five items that the girls retain the best are the following: numbers 21, that part of the body affected in pneumonia; 33, the chemical nature of air; 25, the technical term applied to any living thing; 40, that device which furnishes heat without involving oxidation; 3, the volume of ice resulting from freezing a cubic inch of water. The items in this part which gain in number of errors and hence are poorly retained during the eighteen-week interval are: 32, normal atmospheric pressure at sea level; 10, the definition of saturation; 12, the type of weather indicated by a rising barometer; 38, the meaning of isotherms on a weather map; 7, the electrolysis of water.

In Part II, the girls retain best numbers 5, the resistance of bacteria to sunlight; 38, the function of the Weather Bureau; 40, the contribution of Robert Koch to bateriology; 35, the definition of steam; 22, the rate of reproduction of bacteria. Those items on which retention is the least satisfactory are numbers 18, the normal rate of breathing; 32, the meaning of isobars on the weather map; 39, the function of the white corpuscles of the blood; 30, the definition of humidity; 21, the reaction illustrated by the freezing of water.

A glance at this list shows that questions dealing with

both technical terms and the applications of scientific principles are numbered among the items that are retained as well as among those that are forgotten. A generalization would be invalid on the basis of the available evidence. However, the data seem to indicate that responses calling for the absolute recall of specific fact are forgotten the most by the girls

The boys retain best in Part I numbers 4, the decomposition of water; 6, the definition of a tissue; 5, the effect of increasing the relative humidity; 21, that part of the body affected in pneumonia. They retain least numbers 12, the type of weather indicated by a rising barometer; 24, the reason why the hotter water is found at the top of a hot water tank; 13, the reason why the body is not crushed by the pressure of the atmosphere; 39, the material which forms the basis of life; 29, the characteristics of rapid oxidation.

That true-false item which is best retained by the boys is number 40, the contribution of Robert Koch to bacteriology. Following in order of frequency are numbers 5, the resistance of bacteria to sunlight; 34, the cause of common colds; 24, the effect of altitude on the boiling of water for cooking purposes; 7, the nature of water. The following statements are not well retained: numbers 18, the normal rate of breathing; 32, the meaning of isobars on the weather map; 30, the definition of humidity; 21, the reaction illustrated by the freezing of water; 39, the function of the white corpuscles in the blood.

It is to be noted that the poorly retained items in Part II are identical for both boys and girls, although they do not

stand in the same order. The boys tend to show superiority to the girls in the retention of definitions. They are weak in the applications of principles.

TRUE-FALSE STATEMENTS VS. MULTIPLE-CHOICE ITEMS.

If true-false statements are compared with multiple-choice items, it is found that the multiple-choice tend in general to be retained to a less degree than the true-false. This is true in spite of the fact that true-false statements 18 and 32 lead the list of those test items that suffer the greatest loss. Of the first forty items beginning with that one retained the least, 17 are true-false and 23 are multiple-choice.

FIELDS OF KNOWLEDGE AND RETENTION.

The second basis for the determination of extent of retention involved the grouping of items by fields of knowledge. It will be remembered that the test items represent a sampling of six major divisions of subject matter. These major divisions include the following:

I. Air and how we use it.
   a. Air and air pressure.
   b. Air and fire.
   c. Air and breathing.
   d. Air and health.

II. Water and how we use it.
   a. Water in our homes.
   b. The weather.

Which field of knowledge is retained the least ? Which the best ?

If errors are tabulated for items grouped by topics, the per cent. of error may be computed by dividing the number of errors made in the specific field by the maximum possible number. The difference in per cent. between $T_o$ and $T_{18}$ yields a per cent. of loss or gain during the interval. That field which experiences the greatest gain exhibits the poorest retention, for the per cent. of error has increased. Similarly that field which assumes the smallest increment shows the best retention.

The evidence shows that the girls retain least Field VI—The Weather. Field III—Air and Breathing—also experiences poor retention. In the first case the per cent. of error increases 7.5 ; in the second the increment is 7.0. It would seem that both of these fields, practical and personal as they are, should be well retained. The field which is retained the best is Field II, dealing with Air and Fire. This is a phase of their environment which is comparatively new in its detail to ninth grade pupils.

The boys also retain poorest the material which deals with Air and Breathing and the Weather. But they do retain more than the girls in both of these fields. The best retention for them is in Field IV— Air and Health. This evidence can lead to no conclusive generalization. Material which is concrete and personal is both retained and not retained.

The evidence furnished by this study seems to indicate that boys and girls do not exhibit a marked tendency to retain information highly personal in character. There is no marked tendency to retain best that which is closely related to the

child's immediate environment. Boys do tend to retain such information better than girls. The girls tend to retain best material of a more technical nature.

After an interval of time, are pupils able to apply the scientific principles that have been presented to them or is retention confined to factual material ? In other words what is the relation with regard to retention between judgment questions and those involving mere factual memory ?

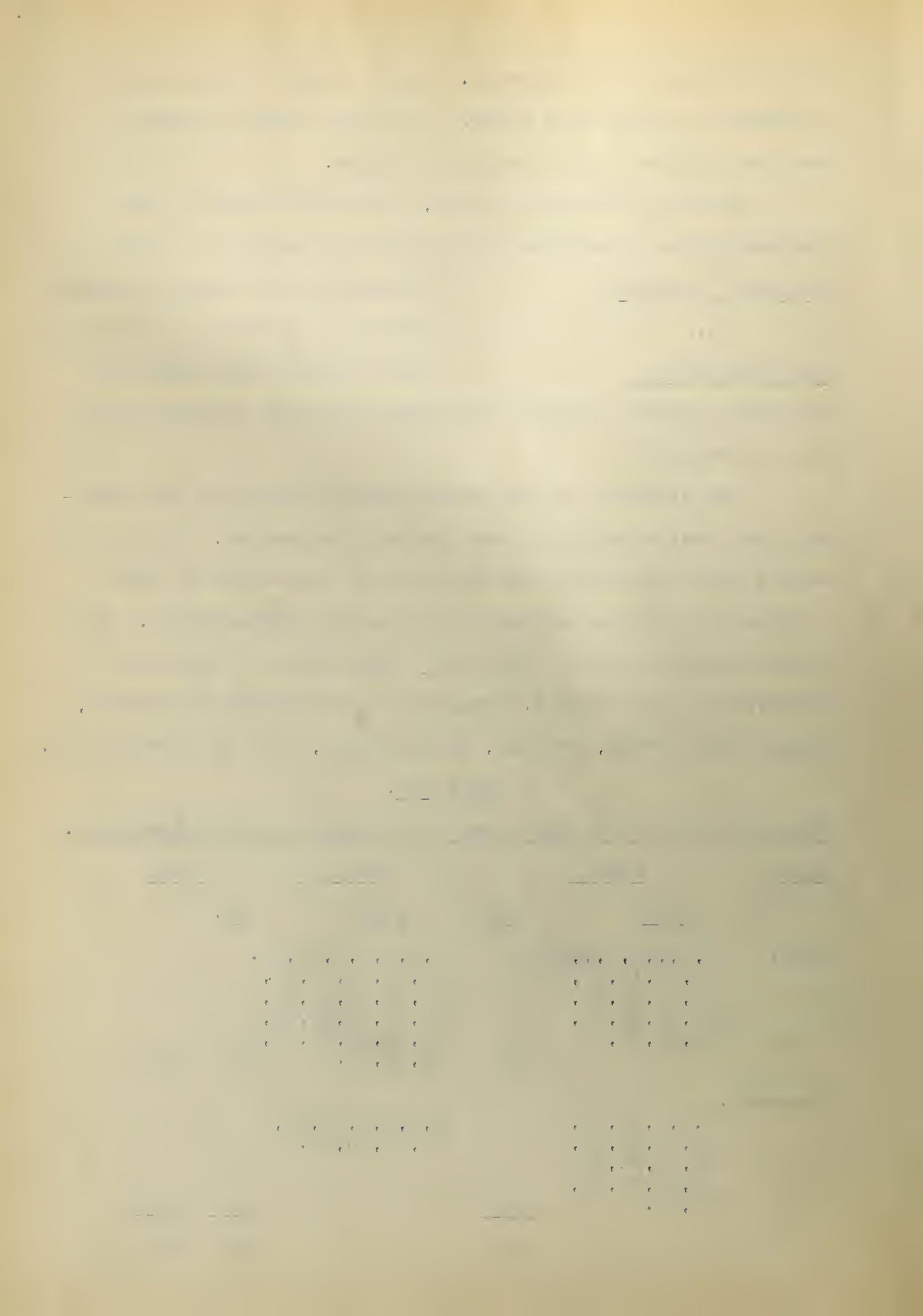
JUDGMENT QUESTIONS vs. FACT QUESTIONS.

The division of the eighty items of the test into judgment and fact questions is at the best subjective. In order to reduce subjectivity as much as possible the questions were divided into the two groups by two people independently. The classification given in Table XVI represents the combined decisions of Mr. Ralph E. Brierley of the science department, Rogers High School, Newport, Rhode Island, and the experimenter.

Table XVI.

Classification of 80 Test Items as Judgment or Fact Questions.

| Type | Part I. | | Part II. | | Total |
|---|---|---|---|---|---|
| | Items | No. | Items | No. | |
| Fact. | 1,2,4,6,7,8, 10,11,17,21, 25,28,30,31, 32,34,35,36, 37,38,39, | 21 | 1,2,5,7,8,11,12. 13,14,15,16,18, 20,21,22,23,25, 27,28,29,30,32, 33,34,35,36,37, 38,39,40. | 30 | 51 |
| Judgment. | 3,5,9,12,13, 14,15,16,18, 19,20,22,23, 24,26,27,29, 33,40. | 19 | 3,4,6,9,10,17, 19,24,26,31. | 10 | 29 |
| | | 40 | | 40 | 80 |



The twenty test items retained the least by the girls (see Table XV) during an interval of eighteen weeks include 33 per cent. of the fact questions and 10 per cent. of the judgment questions. The twenty items retained the best include 24 per cent. of the fact questions and 28 per cent. of the judgment questions. This evidence indicates that the girls tend to retain best knowledge that involves judgment rather than factual material per se.

In the case of the boys 24 per cent. of the fact questions and 28 per cent. of the judgment questions are included in the twenty questions that are forgotten the most. The group of twenty questions remembered best consists of 27 per cent. of the fact questions and 21 per cent. of the judgment. Hence the boys tend to remember best, factual material.

If the group of 144 pupils is considered, it is found that 29 per cent. of the fact items and 17 per cent. of the judgment questions comprise the twenty items retained the poorest. At the other end of the scale, the twenty items retained best include 18 per cent. of the fact questions and 38 per cent. of the judgment questions. This shows that the group as a whole tends to exhibit the best retention with regard to questions involving judgment rather than those involving mere recall of facts. After an interval of time they are better able to apply the principles they have learned and make gereralizations on the basis of them than they are to recall factual material that has been memorized. In this respect the girls are superior to the boys.

## Chapter VI.

## Summary of Conclusions.

On the basis of the evidence furnished by this investigation, the following conclusions may be drawn with regard to the retention of general science knowledge.

1. In an unselected group of ninth grade pupils in general science, great variation exists in the amount of information learned and retained. Some of the pupils learn and retain the major part of the course's content over a period of eighteen weeks, while others learn and retain but little more than 50 per cent..

2. For the group as a whole the maximum amount of forgetting occurs during the six week interval immediately following the initial test. The rate of forgetting is materially decreased during the second interval of twelve weeks.

3. Boys tend to learn more and retain more in proportion to what they learn than girls. This may be due to many factors, including preference for the subject and out-of-school associations.

4. In the main a positive relation exists between retention and mental ability. Those boys superior mentally learn and retain more in proportion to what they learn than their not-so-bright classmates. But even those boys in the lowest quartile of mental age retain most of what they do learn over a whole semester. The girls of superior mental ability do not retain what they learn to as great an extent as those in the lowest quartile.

5. On the basis of the data furnished by this study no generalization can be made with regard to the relation between chronological age and retention. Chronological age is apparently of no value in predicting ability or inability to retain general science knowledge.

6. In general those pupils who like general science tend to retain more of what they learn than those who do not like the subject so well. The data for the girls, however, indicate a negative relationship between subject preference and retention. But the differences are not great enough to produce a marked effect on the group as a whole.

7. Girls tend to retain least, those items that call for the absolute recall of a specific fact. The boys tend to show superiority in the retention of definitions.

8. True-false statements tend to be retained better than multiple-choice items.

9. In the light of the evidence supplied by this study, boys and girls do not exhibit a marked tendency to retain best that information which is highly personal, which is closely related to the environment with which they come in daily contact.

10. During an interval of eighteen weeks pupils tend to retain, best, knowledge which is used in answering questions requiring judgment rather than knowledge which is characterized by the reproduction of memorized facts.

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